Research Proposal

Copper and Zinc Bioavailability

Problem Title. What is the bioavailability of dissolved copper and zinc in highway stormwater runoff?

Problem Statement. In 1992, U.S. EPA recommended that states no longer use total metals as an indicator of toxicity; rather that they use dissolved-phase metals, with the rationale that dissolved-phase metals better indicate actual aquatic toxicity. The standard method for measuring dissolved metals uses a 0.45 micron filter before acid digestion of the sample. However, this method may not accurately measure bioavailable dissolved metals concentrations.

Metals generally pass through the filter as free ions. However, some metal-containing mineral compounds and colloidal particles may also pass through the filter, while some particles larger than 0.45 microns, and therefore be excluded by the filter, may weakly adsorb metal ions. Further, the filter's particle-exclusion characteristics can change during the course of filtration as a result of filter pore plugging and blockage as excluded particles accumulate. In general, the colloidal and mineral-metal complexes tend not to be bioavailable, whereas the free ionic portions are. So while a "dissolved metals" analysis may be a somewhat better indicator of direct toxicity than total metals concentrations, it is still likely to incorrectly estimate toxic effects in receiving waters, as a consequence of uncertainty of the true concentrations of dissolved metals.

WSDOT is faced with technical challenges to improve dissolved copper and zinc removal in BMPs constructed to treat highway stormwater runoff. Uncertainty in dissolved metals concentrations may lead to inadequate treatment, with environmental costs; or over-treatment, with economic costs – which have indirect environmental costs by diverting funds unnecessarily. By using either a "treatment train" approach or by modifying current designs to accommodate improved dissolved metals removal, WSDOT will incur significant expenses designing, constructing, and monitoring these systems for pollutant capture effectiveness.

Literature Search. This is a relatively new research area and is rapidly evolving. Bioavailability and bioaccumulation of metals contained in highway runoff appears to be toxicant and organism-specific. Metals are particularly problematic because of most metal's ability to form multiple organic or inorganic compounds (speciation) in a single sample. To further complicate the issue, metals speciation may change as the background water quality (pH, concentrations, anionic profile) is altered. Many of these compounds can be non-bioavailable and smaller than 0.45 microns, and therefore they can influence apparent dissolved metals concentrations. See the following web site for a discussion of this topic: http://www.eawag.ch/research_e/aqu/e_gruppe_sigg/e_group_sigg.html. A discussion of the complexity and uncertainty in filtration for dissolved metals can be seen at http://www.powellassociates.com/sciserv/Sampling/sampleP1.html.

Research Methods. This is a meta-analysis study – a synthesis of available literature about the topic. This is a highly technical and arcane subject area that has influenced heavy industry to a far greater degree than transportation. Technical literature should be reviewed and reported on periodically, and the relevant results compiled in future updates.

Partnering Opportunities. Nationwide, but sparse. It is unlikely that public agencies outside of universities will be able to fund or conduct relevant research that aids transportation project delivery.

Estimate of Costs and Research Duration. Estimated costs have not been developed, but are expected to be greater than $100,000.

Urgency, Payoff Potential, and Implementation. Research could reduce stormwater management facility costs if technical justification is provided to exempt highway projects from enhanced treatment requirements.

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